

**What is claimed is:**

1. A method for producing gas clathrate, comprising the steps of;

    mixing and dissolving step of mixing a raw material liquid with a raw material gas in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid;

    forming step of cooling the gas-dissolved raw material liquid while forcing the gas-dissolved raw material liquid to flow through a reaction conduit to form the gas clathrate.

2. The method of claim 1, wherein the mixing and dissolving step comprises continuously dissolving the raw material gas in the form of fine bubbles into the raw material liquid.

3. The method of claim 1, wherein

    the mixing and dissolving step comprises without using a reaction vessel, mixing a raw material liquid with a raw material gas in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid;

    the forming step comprises without using a reaction vessel, cooling the gas-dissolved raw material liquid while forcing the gas-dissolved raw material liquid to flow through the reaction conduit to form the gas clathrate.

4. The method of claim 3, wherein the mixing and dissolving step comprises continuously dissolving the raw material gas in the

form of fine bubbles into the raw material liquid.

5. The method of claim 1, further comprising the steps of sending the formed gas clathrate together with the unreacted raw material gas and the raw material liquid through the reaction conduit to a separator.

6. The method of claim 1, further comprising the steps of:  
    sending the formed gas clathrate together with the unreacted raw material gas and the raw material liquid through the reaction conduit to a separator; and  
    subjecting a slurry including the gas clathrate, the unreacted raw material gas and the raw material liquid to a separation and dewatering treatment by the separator to form a high concentration slurry or a solid clathrate.

7. The method of claim 5, wherein the mixing of the raw material liquid and the raw material gas is continuously performed by using a line mixer.

8. The method of claim 6, wherein the mixing of the raw material liquid and the raw material gas is continuously performed by using a line mixer.

9. The method of claim 1, wherein the mixing and dissolving step comprises mixing a raw material liquid with a raw material gas by using a line mixer and dissolving the raw material gas into the raw material liquid.

10. A method for producing gas clathrate, comprising the steps of:

mixing and dissolving step of mixing a raw material liquid with a raw material gas in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid;

forming step of cooling the gas-dissolved raw material liquid while forcing the gas-dissolved raw material liquid to flow through a reaction conduit to form the gas clathrate; wherein,

the mixing and dissolving step comprises mixing a raw material liquid with a raw material gas by using a line mixer which is different from a reaction tank and dissolving the raw material gas into the raw material liquid; and wherein,

the forming step comprising forcing the gas-dissolved raw material liquid to flow through a pipe-shaped reaction conduit which is different from a reaction tank and cooling the surface of the reaction conduit to form the gas clathrate.

11. A method for producing gas clathrate, comprising the steps of:

mixing and dissolving step of mixing a raw material liquid with a raw material gas in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid;

forming steps of cooling the gas-dissolved raw material liquid while forcing the gas-dissolved raw material liquid to flow through a reaction conduit to form the gas clathrate;

sending the formed gas clathrate together with the unreacted raw material gas and the raw material liquid through the reaction conduit to a separator; and

separating the mixture into the gas clathrate, the unreacted raw material gas and the raw material liquid; wherein,

the mixing and dissolving step comprising mixing a raw material liquid with a raw material gas by using a line mixer which is different from a reaction tank and dissolving the raw material gas into the raw material liquid; and wherein,

the forming step comprising forcing the gas-dissolve raw material liquid to flow through a pipe-shaped reaction conduit which is different from a reaction tank and cooling the surface of the reaction conduit to form the gas clathrate.

12. The method of claim 9, further comprising the step of providing a pressure regulating means between the line mixer and the reaction conduit and adjusting a fluid pressure such that the pressure of the line mixer side becomes higher than the pressure of the reaction conduit side.

13. The method of claim 10, further comprising the step of providing a pressure regulating means between the line mixer and the reaction conduit and adjusting a fluid pressure such that the pressure of the line mixer side becomes higher than the pressure of the reaction conduit side.

14. The method of claim 11, further comprising the step of

providing a pressure regulating means between the line mixer and the reaction conduit and adjusting a fluid pressure such that the pressure of the line mixer side becomes higher than the pressure of the reaction conduit side.

15. The method of claim 9, further comprising the step of providing a flow speed regulating means at downstream side of the line mixer and adjusting a flow speed of fluid to reduce the flow speed flowing through the line.

16. The method of claim 10, further comprising the step of providing a flow speed regulating means at downstream side of the line mixer and adjusting a flow speed of fluid to reduce the flow speed flowing through the line.

17. The method of claim 11, further comprising the step of providing a flow speed regulating means at downstream side of the line mixer and adjusting a flow speed of fluid to reduce the flow speed flowing through the line.

18. The method of claim 9, further comprising the step of recycling the unreacted raw material gas and the raw material liquid, which were separated in the separating step.

19. The method of claim 10, further comprising the step of recycling the unreacted raw material gas and the raw material liquid, which were separated in the separating step.

20. The method of claim 11, further comprising the step of recycling the unreacted raw material gas and the raw material liquid, which were separated in the separating step.

21. The method of claim 19, further comprising the step of controlling a liquid level in the separator to give the raw material liquid seal effect so as the gas not to enter the raw material liquid recycle line.

22. The method of claim 20, further comprising the step of controlling a liquid level in the separator to give the raw material liquid seal effect so as the gas not to enter the raw material liquid recycle line.

23. The method of claim 19, further comprising the step of supplying a raw material gas, whose pressure increases by a gas booster, to the separator.

24. The method of claim 20, further comprising the step of supplying a raw material gas, whose pressure increases by a gas booster, to the separator.

25. A method for producing gas clathrate, comprising the steps of:

mixing and dissolving step of mixing a raw material liquid with a raw material gas in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid;

forming step of cooling the gas-dissolved raw material liquid while forcing the gas-dissolved raw material liquid to flow through a reaction conduit to form the gas clathrate; wherein,

the mixing and dissolving step and the forming step is separately performed.

26. The method of claim 25, wherein

the mixing and dissolving step comprises mixing a raw material liquid with a raw material gas by using a line mixer in a production line of gas clathrate and dissolving the raw material gas into the raw material liquid; and

the forming step comprises forcing the gas-dissolved raw material liquid to flow through a pipe-shaped reaction conduit and cooling the surface of the reaction conduit to form the gas clathrate.

27. The method of claim 9, wherein the mixing and dissolving step comprises mixing the raw material liquid and the raw material gas by using the line mixer to convert the raw material gas to fine bubbles and dissolving the fine bubbles into the raw material liquid.

28. The method of claim 10, wherein the mixing and dissolving step comprises mixing the raw material liquid and the raw material gas by using the line mixer to convert the raw material gas to fine bubbles and dissolving the fine bubbles into the raw material liquid.

29. The method of claim 11, wherein the mixing and dissolving step comprises mixing the raw material liquid and the raw material gas by using the line mixer to convert the raw material gas to fine bubbles and dissolving the fine bubbles into the raw material liquid.

30. The method of claim 9, wherein the mixing and dissolving step comprises agitating the raw material liquid, involving the raw material gas in the agitated raw material liquid to convert the raw material gas into fine bubbles, and dissolving the fine bubbles into the raw material liquid.

31. The method of claim 10, wherein the mixing and dissolving step comprises agitating the raw material liquid, involving the raw material gas in the agitated raw material liquid to convert the raw material gas into fine bubbles, and dissolving the fine bubbles into the raw material liquid.

32. The method of claim 11, wherein the mixing and dissolving step comprises agitating the raw material liquid, involving the raw material gas in the agitated raw material liquid to convert the raw material gas into fine bubbles, and dissolving the fine bubbles into the raw material liquid.

33. The method of claim 1, wherein the forming step comprises converting the whole amount of the material gas dissolved in the mixing and dissolving step into the gas clathrate.



34. The method of claim 1, wherein, in the forming step, flow rate of the raw material liquid, pressure of the raw material liquid, flow rate of the raw material gas, pressure of the raw material gas, cooling capacity, reaction conduit length and reaction conduit diameter are determined to be fallen within a range so that the pressure  $P$  at exit of the reaction conduit becomes higher than the minimum pressure  $P_0$  for forming the gas clathrate, so that the temperature  $T$  in the reaction conduit becomes lower than the maximum temperature  $T_0$  for forming the gas clathrate, and so that the raw material gas dissolved in the mixing and dissolving step derives all of formation heat that is accompanied by converting the whole amount of the dissolved raw material gas into the gas clathrate.

35. The method of claim 1, further comprising the step of changing a particle size of the gas clathrate by changing at least one selected from the group consisting of flow speed of the raw material liquid that flows through the reaction conduit, and supply amount of the raw material gas.

36. The method of claim 1, wherein the reaction conduit comprises a plurality of conduits, and wherein

the method for producing the gas clathrate further comprises a step of changing a particle size of the gas clathrate formed in the respective reaction conduits in the forming step by changing at least one selected from the group consisting of flow speeds of the raw material liquid that flows through each

of a plurality of the reaction conduits and flow rate of the raw material gas being fed to the respective reaction conduits.

37. The method of claim 1, further comprising the steps of:

separating the formed gas clathrate by a separator connected with the reaction conduit;

detecting pressure in the separator; and

controlling the pressure in the separator by adjusting at least one selected from the group consisting of flow rate of the raw material gas being fed to the mixing and dissolving step and flow speed of the raw material liquid in the forming step, based on the pressure detected in the pressure detecting step.

38. The method of claim 1, further comprising the steps of:

separating the formed gas clathrate by a separator connected with the reaction conduit;

further mixing and dissolving step of dissolving the raw material gas into the raw material liquid after the mixing and dissolving step, and before the forming step of the gas clathrate or on the way of the forming step of the gas clathrate.

39. The method of claim 1, further comprising the steps of:

successively storing the formed gas clathrate in a transportation tank connected to the reaction conduit; and

dismounting the transportation tank from the reaction conduit to transport to a destination.

40. The method of claim 39, further comprising the step of

concentrating the formed gas clathrate or the step of separating the formed gas clathrate from the raw material liquid.

41. An apparatus for producing gas clathrate, comprising:

a line mixer for mixing a raw material liquid with raw material gas and dissolving the raw material gas in the raw material liquid in a production line of the gas clathrate; and

a reaction conduit, where forcing the gas-dissolved raw material liquid to flow, for forming the gas clathrate by cooling the gas-dissolved raw material liquid.

42. The apparatus of claim 41, the line mixer further comprising means for generating fine bubbles of the raw material gas.

43. The apparatus of claim 41, further comprising pressure regulating means at downstream side of the line mixer for adjusting line pressure.

44. The apparatus of claim 42, further comprising pressure regulating means at downstream side of the line mixer for adjusting line pressure.

45. The apparatus of claim 41, further comprising flow speed regulating means for adjusting flow speed of the fluid that flows through the line.

46. The apparatus of claim 42, further comprising flow speed regulating means for adjusting flow speed of the fluid that

flows through the line.

47. The apparatus of claim 43, further comprising flow speed regulating means for adjusting flow speed of the fluid that flows through the line.

48. The apparatus of claim 41, further comprising the apparatus other than a tank-shape pressure vessel for mixing a raw material liquid with a raw material gas and dissolving the raw material gas in the raw material liquid and for cooling the gas-dissolved raw material liquid.

49. The apparatus of claim 48, wherein the line mixer further comprising means for generating fine bubbles of the raw material gas.

50. The apparatus of claim 48, further comprising a pressure regulating means at downstream side of the line mixer to adjust line pressure.

51. The apparatus of claim 49, further comprising a pressure regulating means at downstream side of the line mixer to adjust line pressure.

52. The apparatus of claim 48, further comprising flow speed regulating means to adjust flow speed of fluid flowing through the line.

53. The apparatus of claim 49, further comprising flow speed regulating means to adjust flow speed of fluid flowing through the line.

54. The apparatus of claim 41, further comprising a separator for separating the gas clathrate, the unreacted raw material gas and the raw material liquid, which are formed in the reaction conduit.

55. The apparatus of claim 54, wherein the line mixer comprises means for generating fine bubbles of the raw material gas.

56. The apparatus of claim 54, wherein the separator comprises at least one selected from the group consisting of a decanter, cyclone, a centrifugal separator, a belt press, a screw concentrator dehydrator, and a rotary drier.

57. The apparatus of claim 41, further comprising:

gas flow rate regulating means for adjusting flow rate of the feeding raw material gas;

gas pressure regulating means for adjusting the raw material gas pressure;

raw material liquid flow rate regulating means for adjusting flow rate of the feeding raw material water;

raw material liquid pressure regulating means to adjust pressure of the raw material liquid;

cooling unit for cooling the reaction conduit; and

pressure regulating means for adjusting the pressure in

the reaction conduit; wherein

the gas flow rate regulating means, the gas pressure regulating means, the raw material liquid flow rate regulating means, the raw material pressure regulating means, cooling capacity of the cooling unit, length of the reaction conduit, and diameter of the reaction conduit are determined to be controlled so that the whole amount of the raw material gas supplied into the line mixer are converted into the gas clathrate.

58. The apparatus of claim 41, further comprising:

gas flow rate regulating means for adjusting flow rate of the feeding raw material gas;

gas pressure regulating means for adjusting the raw material gas pressure;

raw material liquid flow rate regulating means for adjusting flow rate of the feeding raw material liquid;

raw material liquid pressure regulating means for adjusting pressure of the raw material liquid;

a cooling unit for cooling the reaction conduit; and

pressure regulating means for adjusting the pressure in the reaction conduit; wherein

the gas flow rate regulating means, the gas pressure regulating means, the raw material liquid flow rate regulating means, the raw material liquid pressure regulating means, cooling capacity of the cooling unit, length of the reaction conduit, and diameter of the reaction conduit are determined to be controlled so that the pressure  $P$  at exit of the reaction

conduit becomes higher than the minimum pressure  $P_0$  for forming the gas clathrate, the temperature  $T$  in the reaction conduit becomes lower than the maximum temperature  $T_0$  for forming the gas hydrate, and the raw material gas supplied into the line mixer derives the whole amount of the formation heat, which is accompanied by converting all of the dissolved raw material into the gas clathrate.

59. The apparatus of claim 57, further comprising:

a pressure detector for detecting pressure at exit of the reaction conduit, to adjust at least one selected from the group consisting of the gas flow rate regulating means and the raw material liquid flow rate regulating means, when pressure value detected by the pressure detecting means exceeds a predetermined level.

60. The apparatus of claim 58, further comprising:

a pressure detector for detecting the pressure at exit of the reaction conduit to adjust at least one selected from the group consisting of the gas flow rate regulating means and the raw material liquid flow rate regulating means, when pressure value detected by the pressure detecting means exceeds a predetermined level.

61. The apparatus of claim 57, wherein the line mixer comprises means for generating fine bubbles of the raw material gas.

62. The apparatus of claim 58, wherein the line mixer comprises

means for generating fine bubbles of the raw material gas.

63. The apparatus of claim 41, further comprising a flow speed controlling means for changing the flow speed of the raw material liquid that flows through the reaction conduit.

64. The apparatus of claim 41 having a plurality of conduits, further comprising:

flow speed controlling means for changing the flow speed of the raw material water that flows through the plurality of reaction conduits, wherein the flow speed controlling means controls so as the respective flow speed of the raw material liquid flowing through the individual reaction conduit to be different from each other.

65. The apparatus of claims 41, further comprising gas flow rate regulating means for adjusting flow rate of the raw material gas that is fed into the line mixer.

66. The apparatus of claim 41, wherein

the apparatus has a plurality of the line mixers and a plurality of the conduits;

the plurality of the line mixers have raw materials gas flow rate regulating means respectively, wherein the raw material gas flow rate regulating means control the flow rate of the raw material gas so that the flow rate of the raw material gas that flows through the individual reaction conduit is different from each other.



67. The apparatus of claim 54, further comprising:

gas flow rate regulating means for adjusting material gas flow rate to be supplied;

pressure detecting means for detecting pressure in the separator;

control means for adjusting at least one selected from the group consisting of the gas flow rate of the flow rate regulating means and the flow speed of the raw material liquid flow speed regulating means, based on the pressure value detected by the pressure detecting means.

68. The apparatus of claim 67, wherein the line mixer further comprises means for generating fine bubbles of the raw material gas.

69. The apparatus of claim 54, wherein at least one piece of the line mixer is located on upstream side of the reaction conduit, simultaneously with locating a single of the line mixer or a plural of the line mixer on the way of the reaction conduit.

70. The apparatus of claim 69, the line mixer further comprising means for generating fine bubbles of the raw material gas.

71. The apparatus of claim 69, further comprising a pressure regulating means at downstream side of the line mixer to adjust line pressure.

72. The apparatus of claim 70, further comprising a flow speed regulating means for adjusting flow speed of the fluid that flows through the line.

73. The apparatus of claim 69, further comprising flow speed regulating means for adjusting flow speed of the fluid that flows through the line.

74. The apparatus of claim 70, further comprising flow speed regulating means for adjusting flow speed of the fluid that flows through the line.

75. The apparatus of claim 41, further comprising:

a transportation tank, which is detachably connected with the reaction conduit, which stores the gas clathrate formed in the reaction conduit, and which is dismounted from the reaction conduit after the transportation tank is filled with the gas clathrate for transporting the gas clathrate to destination.

76. The apparatus of claim 75, further comprising at least one selected from the group consisting of a concentration unit for concentrating the produced gas hydrate and a separator for separating the produced gas hydrate from the raw material liquid.